ATLANTIS PRESS

Advances in Economics, Business and Management Research, volume 178

Proceedings of the 2021 International Conference on Enterprise Management and Economic Development (ICEMED 2021)

Evolutions of Economic Zones' Interaction in Innovation

Based on the Three-dimensional Analysis of Organization, Geography and Technology

Fei-Fei YAN [1] Xiao-wen Wang [2,*] Wen-Sheng YANG[3]

[1] *College of Economics and Management, Dalian University, Dalian 116622, China*
[2] *College of Economics and Management, Dalian University, Dalian 116622, China*
[3] *College of Economics and Management, Dalian University, Dalian 116622, China*
[*]*Corresponding author. Email: 1494204083@qq.com*

ABSTRACT

This paper proposes a three-dimensional analytical framework, and applies the framework to the longitudinal analysis of China's four economic zones' interaction in innovation by examining collaborative invention patent applications from 1985 to 2015. The results showed that, first, the spatial distribution of interaction in innovation is imbalanced and there exists different forms of spatial distribution between the East and the other three zones; second, the organization patterns of inter- and intra-economic zone interaction in innovation are varied not only in different economic zones but also in in different periods; third, the technological distribution of interaction in innovation is relatively concentrative, and the dominated technological fields change by using 2006 as dividing point, but for inter- and intra-economic zone interaction in innovation, there are no significant differences.

Keywords: *Economic zone, Interaction in innovation, Evolution, Three-dimensional analytical framework*

1. INTRODUCTION

Regional coordinated development strategy, whose strategic objectives are to promote the coordinated development of the eastern region, the central region, the western region and the northeast industrial base (Four Economic Zones), and to build sound regional coordination mechanisms for interaction, is an important way to narrow the regional difference in innovation. To this end, the interaction is the key, especially in the context of strengthening innovation. So, an increasing number of scholars have paid attention to the features, and the patterns of economic zones' interaction in innovation.

One important strand of literature deals with intra-economic zone' interaction in innovation [1,2]. Relevant studies mainly investigated the evolution of science knowledge network, the spatial structure and cooperative path of economic tie network, and the industrial division and coordination mechanism in Yangtze River Delta, Jing-jin-ji, and Pan-Pearl River Delta, which are regarded as the representation of an economic zone. Another strand of literature highlights the differences of intra-economic zone interaction in innovation between two economic zones [3,4]. By analysing the dynamic features of inter-regional economic tie networks of typical urban agglomerations, these studies discovered that, different cities worked differently, and the differences of economic connection among cities within a zone had a great impact on synergetic development of urban agglomerations. There exist some drawbacks as follows: first, scholars paid more attention to intra-economic zone interaction in innovation or the differences between economic zones but ignored inter-economic zone interaction; second, studies mainly focused on typical urban agglomerations in Eastern advanced zone, but showed less concern for the ones in Midwest developing zones; third, scholars emphasized on the spatial or organizational characteristics more than technological characteristics which should be viewed as an important consideration. In this paper, we propose a three-dimensional analytical framework which is applied to the longitudinal analysis of China's four economic zones' interaction in innovation by using invention patenting activities as a measure, to make up these above limitations.

Copyright © 2021 The Authors. Published by Atlantis Press B.V.
This is an open access article distributed under the CC BY-NC 4.0 license -http://creativecommons.org/licenses/by-nc/4.0/.

The remainder of this paper is structured as follows. The next section presents a framework for studying the evolutions of economic zones' interaction in innovation. Then it follows the empirical study from China's four economic zones, including data, methods and research results. The last section offers conclusions and implications.

2. RESEARCH FRAMEWORK

We present a three-dimensional analytical framework of evolutions of economic zones' interaction in innovation which can combine spatial characteristics, organization patterns and technological characteristics (see Figure 1).

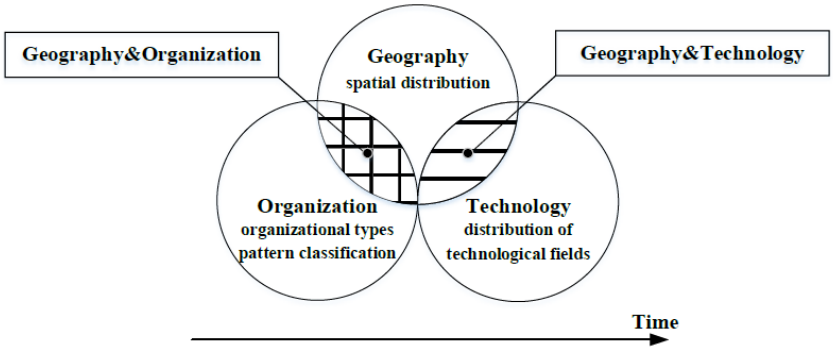

Figure 1 Three-dimensional analytical framework

Geographical distribution. According to the previous studies [5-7], inter-regional R&D collaboration can be seen as activities of joint R&D innovation by organizations from different regions, so it is often regarded as an important embodiment of innovation resource flow, which represents a form of regional interaction in innovation. We further add the boundary of economic zone, thus two types of interaction in innovation can be identified: intra- and inter-economic zone interaction in innovation. The former reflects the level of interaction in innovation among regions within an economic zone, the more the number of collaborations is, the more frequently regions within an economic zone interact. The later reflects the degree of openness among economic zones, the more the number of collaborations is, the more frequently regions among economic zones interact.

Organization pattern. Enterprise(E) and academic institution(A) are the two most important organizational types for innovation. Based on the theory of regional innovation system, enterprise, as the main body of technological innovation, mainly conducts knowledge absorption and knowledge application; and academic institution, as the main body of knowledge innovation, mainly carries out knowledge creation and knowledge diffusion. The differences in knowledge base, research nature, research goal, and incentive mechanism, exit between the two, makes knowledge flow between them necessary [8-11]. By analysing invention patents that stem from a corporate environment, an academic environment or a combination of the two, three organization patterns can be identified (see Figure 2): collaboration between enterprises (EE), collaboration between academic institutions (AA), and collaboration between enterprise and academic institution (EA). Moreover, we can assume that, knowledge flows are undirected in the two patterns EE and AA, in which patterns collaborations occur between same type of organizations, however, knowledge flows are directed from academic institution to enterprise in the pattern EA, in which pattern collaborations occur between different types of organizations. With respect to inter-economic zone interaction in innovation, the pattern EA can further be subdivided into two sub-patterns: E←A (enterprise in one economic zone absorbs knowledge from academic institution in another one), A→E (academic institution in one economic zone spreads knowledge to enterprise in another one).

Technological distribution. Each co-invention patent has one or more patent numbers, and each patent number represents a certain technological field, which corresponds to a section in International Patent Classification (IPC). All IPC information of co-invention patents after being summarized at the economic zone scale, can provide technological distribution, which reflects the technological path, of economic zones' interaction in innovation.

According to the framework above, first, we can investigate the evolution characteristics of spatial distribution of economic zones' interaction in innovation. Second, we can distinguish the evolution characteristics of organization patterns of economic zones' interaction in innovation based on Geography and Organization dimensions. Third, we can conclude the evolution characteristics of technological distribution of economic zones' interaction in innovation based on Geography and Technology dimensions.

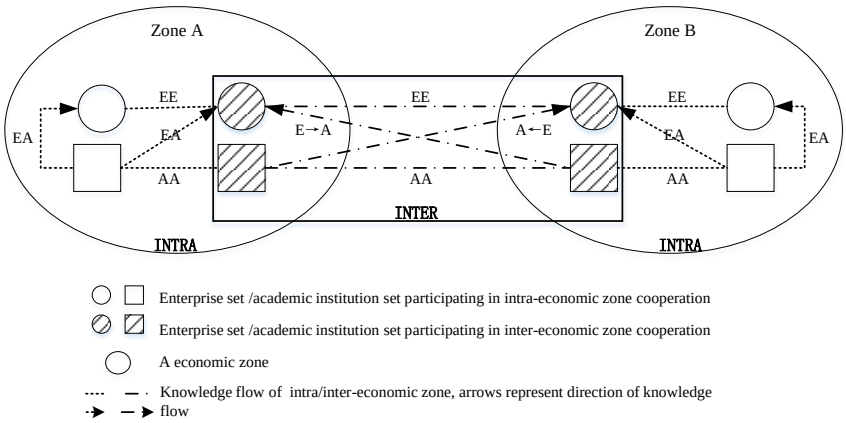

Figure 2 Organization patterns of economic zones' interaction in innovation

3. DATA AND METHODS

Empirically, data on co-patent (especially co-invention) is usually used to measure R&D collaboration. By taking advantage of the patent data in State Intellectual Property Office (SIPO), we apply co-patents to our analysis. The SIPO database was searched in Jun 2016. We draw China's patent application data between 1985 and 2015. Then we did the data processing as follow: first, patents with two or more organizational assignee names were kept; second, the information of above organizations' address were identified (organizations from foreign counties, Hong Kong SAR, Macao SAR and Taiwan (China) were dropped); third, the organizational types were identified, specifically, for industry sectors, assignee names could be company (gongsi), factory (chang), group (jituan), or enterprise (qiye); for academic sectors, assignee names could be university (daxue), college (xueyuan), research centre (yanjiuzhongxin) or institute (yanjiusuo); fourth, we split co-invention into pairs of inter-organizational collaboration, then deleted the pairs of organizations who came from the same region, so far we got all the data of China's inter-regional R&D collaboration. According to the two attributes of organizational type and address, we gathered these pairs at the economic zone level. In order to illustrate the dynamics of economic zones' interaction in innovation, we divided the entire time into three periods of unequal length: 1985-1998, 1999-2006, and 2007-2015. 1999 and 2006 were viewed as the two key years, taking into account the evolution of China's economic transition and the reform of S&T system.

Two main methods were used in our research: descriptive statistical analysis and social network analysis. By using the method of descriptive statistical analysis, the numbers of economic zones' interaction in innovation in three periods were counted in order to describe the evolutions of spatial distribution, the proportions of organization patterns of intra/inter-economic zone interaction in innovation and their changes were calculated in order to identify the evolutions of organization pattern, and the technological fields of economic zones' interaction in innovation were counted in order to investigated the evolutions of technological distribution. By using the method of social network analysis, the network evolution graph of economic zones' interaction in innovation were drawn to recognize the roles of different organizations played in interaction.

4. EMPIRICAL RESULTS

4.1. Evolutions of Spatial Distribution

We counted the numbers of economic zones' interaction in innovation in three periods. As Table1 shows, the total number of interactions in innovation in four economic zones all increased in each period. Moreover, the East ranked the first while the West ranked the last during the entire time. Through analysis of the proportion, we found that, for the Northeast, West and Central, the proportions of the inter-economic zone interaction in innovation were all up to more than 86%, so the three economic zones were all export-oriented model in innovation. However, for the East, the two proportions of the intra- and inter-economic zone interaction in innovation were almost the same, so the East was the equilibrium model in innovation. Besides, we also found that, few interactions were established among the Northeast, West and Central, but more interactions were formed between the East and the three above economic zones.

Table 1. The numbers of economic zones' interaction in innovation in three periods

Numbers	1985-1998				1999-2006				2007-2015			
	East	Northeast	West	Central	East	Northeast	West	Central	East	Northeast	West	Central
East	624				3617				88235			
Northeast	332	24			1176	40			13176	483		
West	194	23	30		850	32	62		20563	634	1555	
Central	298	41	42	60	924	31	70	45	29383	436	2361	1075

Total	1448	420	289	441	6567	1279	1014	1070	151357	14729	25113	33255
Intra	624	24	30	60	3617	40	62	45	88235	483	1555	1075
Inter	824	396	259	381	2950	1239	952	1025	63122	14246	23558	32180

4.2. Evolutions of Organization Pattern

We calculated the organization patterns of intra- and inter-economic zone interaction in innovation and their changes in three periods.

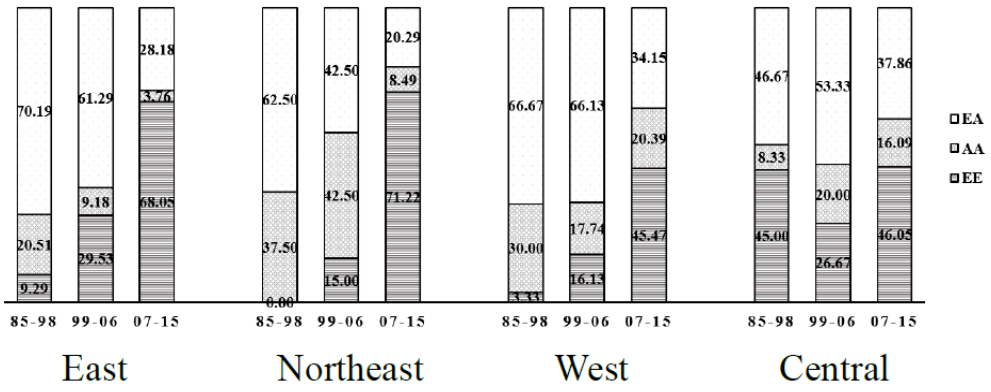

Figure 3 Organization patterns of intra-economic zone interaction in innovation

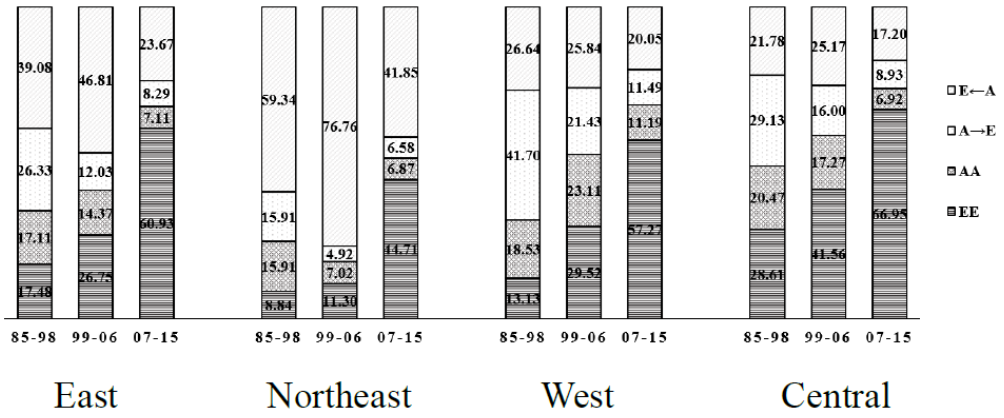

Figure 4 Organization patterns of inter-economic zone interaction in innovation

Figure 3 shows the proportions of three organization patterns of intra-economic zone interaction in innovation and their changes. During the first two periods, the pattern EA dominated, meantime, the proportion of the pattern EE had grown in the East and in the West, the pattern AA maintained a relatively high proportion in the Northeast, however, the proportion of the pattern EE decreased and the proportion of the pattern AA increased in the East. In the last period, the proportion of the pattern EE ranked the first and the proportion of the pattern AA ranked the last in four economic zones. Figure 4 shows the proportions of four organization patterns of inter-economic zone interaction in innovation and their changes. During the first two periods, the pattern E←A dominated in the East and in the Northeast, for the West, the pattern A→E dominated in the first period but four patterns developed in balance in the second period, for the Central, four patterns developed in balance in the first period but the pattern EE dominated in the second period. In the last period, the pattern EE dominated and the pattern E←A took the second place in four economic zones, in addition, the sum of the proportion of the two patterns was far greater than the sum of the other two ones, which indicated that the role of enterprise in promoting the inter-economic zone interaction in innovation became more important.

In order to recognize the roles of different organizations played in interaction, we drew the network evolution graph of economic zones' interaction in innovation by using the social network analysis tool UCINET (see Figure 5). In interaction network, the nodes are the two types of organizations (E or A), the size of node reflects the number of intra-economic zone interactions in innovation, the lines reflected the number of interactions in innovation between two nodes. As Figure 5 shows, in the first period, interactions in innovation mainly occurred within the East, which meant the East realized the knowledge circulation itself, it had become knowledge hub, not only its academic institutes spread knowledge to enterprises in the Central, but also its enterprises absorbed knowledge from academic institutions in the Central and in the West, in addition, the

interaction between the Central and the East enterprises also behaved well. In the second period, interactions within the East, interactions between the East and the Central enterprises, and interactions between academic institutions in the East and enterprises in the Northeast, all had been further strengthened. In the last period, besides the East, the interaction between enterprises began to grow, especially enterprises between the East and the other three economic zones interact well. Academic institutions in the East were still the knowledge hub. Moreover, we also found that, enterprises in the West got lively, they began to establish relationships with organizations in the East.

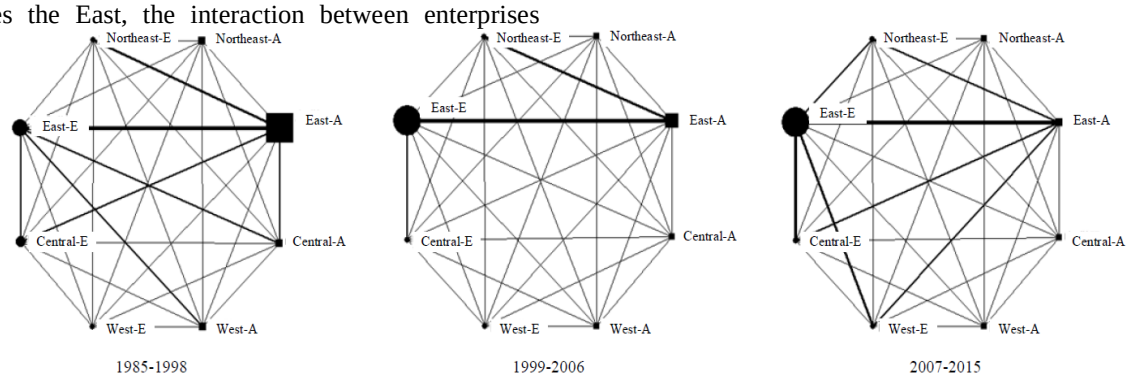

Figure 5 Network evolution of economic zones' interaction in innovation

4.3. Evolutions of Technological Distribution

Table 2. Top 3 technological fields of economic zones' interaction in innovation

IPC		1985-1998			1999-2006			2007-2015		
		No.1	No.2	No.3	No.1	No.2	No.3	No.1	No.2	No.3
Intra	East	C	B	A	C	B	H	G	C	H
	Northeast	G	C	B	C	B	G	B	C	G
	West	C	A	D	C	A	B	C	H	G
	Central	C	B	A	C	B	A	C	G	E
Inter	East	C	B	A	C	B	A	G	C	H
	Northeast	C	B	A	C	B	A	C	B	G
	West	C	B	A	C	A	H	G	C	H
	Central	C	B	A	C	A	B	G	H	C
	East-Northeast	C	B	A	C	B	A	C	B	G
	East-West	C	B	A	C	A	H	G	C	H
	East-Central	C	B	A	C	A	B	G	H	C
	Northeast-West	C	G	A	A	H	C	C	G	H
	Northeast-Central	C	B	A	C	B	A	C	H	G
	West-Central	C	B	F	C	B	H	C	G	H

Table 2 shows top 3 technological fields of economic zones' interaction in innovation. The East held obvious numerical superiority in almost all technological fields. For intra-economic zone interaction, Chemistry and Metallurgy was always the hot field for interaction in the entire time, Physics dominated in the Northeast during the first two periods, and reached the top three in all economic zones in the third period. Electricity became more important for interaction in the East and in the West over time. For inter-economic zone interaction, in the first period, interactions the East participated in, mainly focused on Chemistry and Metallurgy, Operations and Transporting, Human Necessities, while interactions among the other three zones only centered on Chemistry and Metallurgy. In the second period, interactions the West participated in began to perform well in Physics. In the third period, except Chemistry and Metallurgy, Operations and Transporting and Human Necessities had been gradually substituted by Physics and Electricity.

5. CONCLUSIONS AND IMPLICATIONS

In this study we try to enrich the existing research by proposing a three-dimensional analytical framework for studying the evolutions of economic zones' interaction in innovation. An empirical study based on the long China's co-patent data at the economic zone level has been conducted. According to the empirical results, we achieve three important findings.

First, the spatial distribution of interaction in innovation is imbalanced due to regional disparity of innovation capability. The East, whose whole level of interaction was highest, was the equilibrium model and

established a lot of relationships with others, while the other three zones, whose whole level of interaction were lower, were export-oriented model and established few relationships with each other. Second, the organization patterns of interaction in innovation change over time.

Second, the organization patterns of interaction in innovation change over time. Before 2006, interaction in innovation mainly depended on directed knowledge flows from academic institution to enterprise, so it often occurred between different types of organizations. After 2006, with the increasingly establishment of the dominant position of enterprises in technological innovation, the role of enterprises in interaction become more and more important.

Third, the technological distribution of interaction in innovation is relatively concentrative and similar in four economic zones, the dominated technological fields change from labor-intensive ones to technology-intensive ones, using 2006 as the dividing point.

In the Chinese context, the discussion about economic zones' interaction in innovation maybe bring more policy implications. The multi-dimensional analysis perspective helps us to get the whole picture of interaction in innovation, only in this way can the state guide inter-regional knowledge flow and solve regional imbalance by making some pointed policies. For instance, the roles of innovative organizations need to be recognized and fully played, the industrial distribution should be further optimized and the industrial transformation of the late-developing economic zones should be speeded up.

AUTHORS' CONTRIBUTIONS

A three-dimensional analytical framework, which is applied to the longitudinal analysis of China's four economic zones' interaction in innovation by using invention patenting activities as a measure.

ACKNOWLEDGMENTS

This research was financially supported by Doctoral Fund of DLU (2020QW004).

REFERENCES

[1] Jian-cheng Li, Qing-xi Wang, Gen-nian Tang. Dynamic evolution of scientific knowledge network in the Yang Tze River Delta[J]. Studies in Science of Science, 2017, 35(2): 197-205.

[2] Xi-qiang Chen, Yuan-hai Fu, Yun Luo. Research on the impacts of the government-led regional economic integration strategy on structural optimization of manufacturing industry—A case study of the Pan-Pearl River Delta Region[J]. China Soft Science, 2017(9): 69-81.

[3] Wei Zheng, Wen-lu Xu, Yue Chen. Dynamic evolution of economic network within inter-regional urban agglomerations: Based on the urban agglomerations of West Coast of Taiwan Straits, Yangtze River Delta and Pearl River Delta[J]. Economic Geography, 2019, (7): 58-66, 75.

[4] Li-hua Wei. A comparative study of economic relation among three major urban agglomerations in China[J]. Economic Review, 2018, (1): 45-54.

[5] Wei Hong, Yu-Sung Su. The effect of institutional proximity in non-local university-industry collaborations: an analysis based on Chinese patent data[J]. Research Policy, 2013, 42(2): 454-464.

[6] Feng-chao Liu, Fei-fei Yan, Rong-kang Ma, etc. The impact of proximity on inter- regional R&D collaboration patterns: An empirical research based on Beijing, Shanghai and Guangdong[J]. Science Research Management, 2014, 35(11): 454-464.

[7] Yu-tao Sun. The structure and dynamics of intra-and inter-regional research collaborative networks: The case of China (1985–2008) [J]. Technological Forecasting and Social Change, 2016, 108: 70-82.

[8] Feng-chao Liu, Fei-fei Yan, Na Zhang. Evolutions of China's Inter-regional R&D Collaboration Patterns: Based on the Three-dimensional Analysis of Organization, Geography and Technology[C]. Proceedings of the 6th International Conference on Management Science and Management Innovation, ISBN:978-94-6252-741-6, ISSN:2352-5428, 2019, 84:129-134.

[9] Von Proff S, Dettmann A. Inventor collaboration over distance: a comparison of academic and corporate patents [J]. Scientometrics, 2013, 94(3): 1217-1238.

[10] Feng-chao Liu, Fei-fei Yan, Rong-kang Ma, etc. Multi-dimensional proximities and inter-regional R&D collaboration pattern[J]. Studies in Science of Science, 2020, 36(8): 1038-1047.

[11] Crescenzi R, Filippetti A, Iammarino S. Academic inventors: collaboration and proximity with industry [J]. The Journal of Technology Transfer, 2017, 42(4): 730-762.